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ABSTRACT

Forecasts of the opportunities and requirements that will face the American labor force are presented and discussed. The emphasis is on exploring the distribution of skills, temperaments and other individual characteristics of the labor force in 1960 and to systematically, as contrasted to subjectively and impressionistically, forecast their distribution for 1975. Two primary sources of data are analyzed: (1) a draft version of Tomorrow's Manpower Needs, a publication of the Bureau of Labor Statistics; and (2) a magnetic tape containing information (for 13,755 occupational titles) about aptitudes, physical demands, and working conditions associated with these occupations. How this information was treated, and why, comprise part of the content. (TL)

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Some Workforce Requirements Implied By Current Manpower Forecasts

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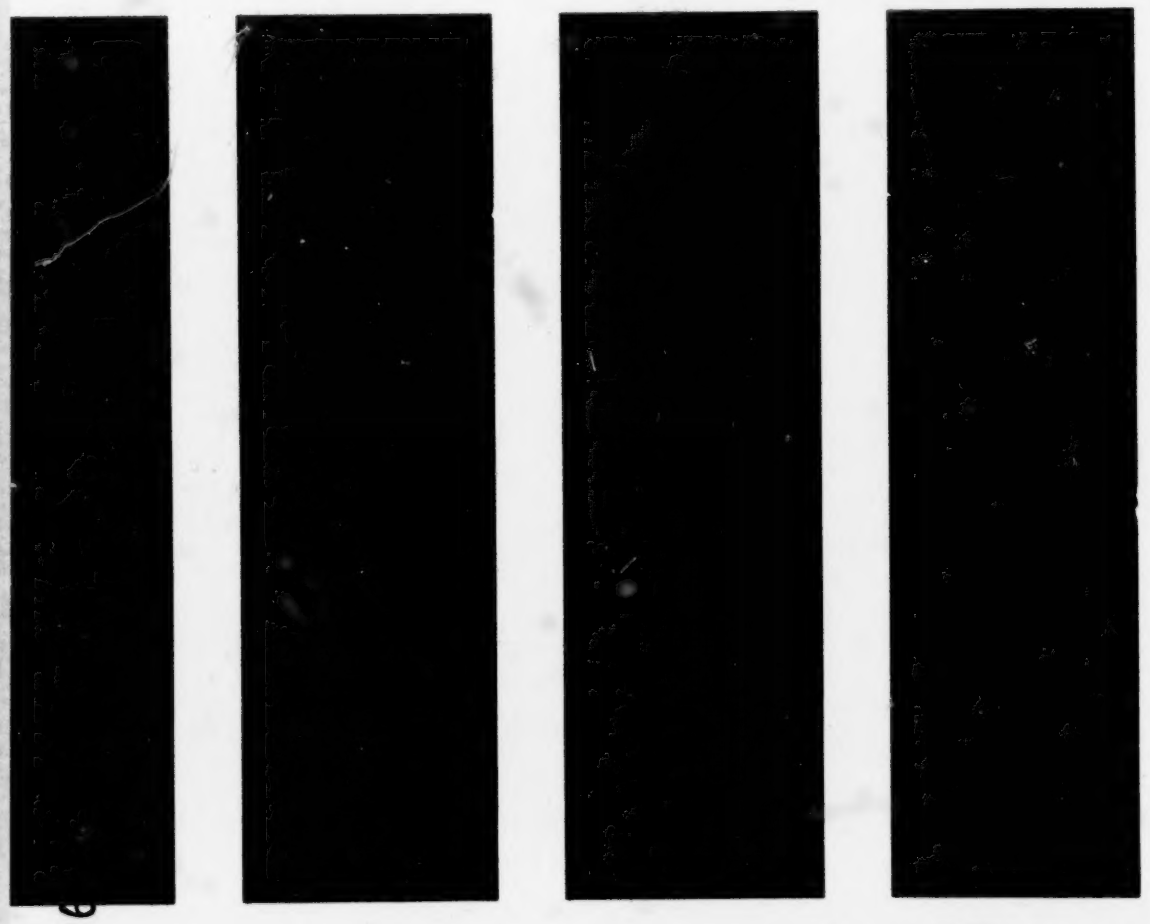

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Harvard-NEEDS-Newton
Information System for Vocational Decisions

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SOME WORKFORCE REQUIREMENTS IMPLIED BY CURRENT MANPOWER FORECASTS

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Introduction

TECHNOLOGICAL and social changes are accelerating as the United States passes beyond industrialization, towards new definitions of work and community. Faced with widespread pressures induced by these changes, we need more than ever to understand where our society is moving; to evaluate that movement; and then to prepare to accept it, or to attempt consciously to change its direction. One reaction to this need has been an increasing number of attempts to forecast the development of our society in general, and of its several sectors. Forecasts of the opportunities and requirements that will face the American labor force have received much attention. This paper will present and discuss some forecasts in that area, with emphasis on the individual traits needed by members of the workforce.

Up to now predictions of changes in the nature of work have been subjective and general rather than systematic. Herman Kahn's predictions are of this kind (see References). Peter Berger asserts that the capacity of work to provide personal satisfaction is decreasing. Henry Borow suggests that the average work week will decrease so greatly that people will find fulfillment in leisure activities rather than through work. But Eli Ginzberg indicates that work is actually more fulfilling than in the past. We need to add to these informed guesses systematic predictions of change (beyond those of employment by occupation and industry) if we are succesfully to evaluate social and psychological changes.

Manpower plans, which have been a principal means of linking educational change to changes in the labor force, reveal the need for growth of certain occupational groups or educational levels. But elementary and secondary schools and most colleges teach general skills rather than occupations. The young person enters the labor market with these skills, which he then applies to one of several possible

occupations. He may later leave his job in search of another which better utilizes his personal traits. Thus knowledge of the distribution of skills in the labor force is relevant both to the activities of schools and to the choices of individual workers.

The need for estimates of requirements of the work force for individual characteristics has long been recognized, as by Leon Lewis, one of the developers of the *Dictionary of Occupational Titles*, in the below statement (Reference 7):

> By determining the distribution of all worker traits factors, a worker traits profile of the working population can be developed. This could be a milestone in such manpower planning activities as facilitating utilization of available skills in the labor force.

With this in mind, this paper proposes to explore the distribution of skills, temperaments, and other characteristics of the labor force in 1960 and to forecast their distribution in 1975. How many workers, for instance, need to work with data; how many must work outdoors; or how many need to have high intellectual capacity?

The near-simultaneous appearance of two valuable sources of information suggested the present research. Recent efforts by two offices of the United States Department of Labor had made available: 1) forecasts in unusual detail of employment by occupation; and 2) extensive information, for a very large number of occupations, of the individual characteristics required of workers. Further, this information was available in a form suitable for machine processing. Certain guesses, approximations, and computational sins lay between us and the effective use of this information. The following pages deal with how the information was treated and why; and with individual characteristics that members of the United States work force need in 1960, and might need in 1975. Throughout, we seek to be specific about the quality of data, of our method of treating it, and of the implications carried by the results of our work.

Forecasts of any kind offer a perilous challenge. They may be highly useful in planing for an uncertain future, but they can also mislead the unwary who put excess trust in their frail accuracy. These hazards are not enough to prevent making such forecasts; but they suggest need for care and caution in interpreting them.

Summary

Two primary sources of information were used in this work:

1. A draft version of *Tomorrow's Manpower Needs* (TMN), made available by the Bureau of Labor Statistics, which includes estimates of 1960 and 1975 employment for 161 occupational groups covering the entire labor force.
2. A magnetic tape containing information similar to, but more extensive than, that in the *Supplement to the Dictionary of Occupational Titles* (DOT) for 13,755 specific occupational titles — information about aptitudes, training, temperaments, physical demands, and working conditions associated with these occupations. This tape was furnished by the Bureau of Employment Security.

Thus, on one hand we had forecasts of employment in terms of numbers of workers; and on the other hand, estimates of the characteristics "required" of workers. Laying aside for now questions relating to reliability of these data and to their stability in time, the central difficulty was that the occupational categories covered by the TMN-data were different from those of the DOT-data. Work under way by the Departments of Labor and Commerce promised to provide a translation between these two sets of categories. Being unwilling to wait, we devised a makeshift translation, described later in this paper. Based on this, the two sources of information were combined to give estimates of the requirements on the workforce in 1960 and 1975.

In the following we shall first present these estimates, and what they seem to imply. After that we shall describe the methods used, and discuss the apparent collective effect of the several liberties we have taken. The results cannot be taken as exact predictions of things to come, an impossibility by any means. The reason for making forecasts is instead carefully to extend conventional wisdom as a point of departure for explanation of actual events. Though these may vary greatly from the forecasts (particularly in their detail), the latter remain valuable indicators of the direction in which events are tending.

Results

The central body of data used in this work is contained in the magnetic tape mentioned above. For 13,755 occupational titles (13,777 from the tape as received, less 22 lost through computational mishaps), information is given for 41 variables. These are summarized in Table 1. For further information about their meaning the reader is referred to the *Dictionary of Occupational Titles,* Volume II, pages 649-56. Some, but not all, of the information on this tape (referred to henceforth as the "DOT-tape") is contained in the *Supplement to the Dictionary of Occupational Titles.*

Two major computations were performed using the DOT-tape:

1. A factor analysis of all 41 variables, using a sample of every tenth title from the tape, and a program of the DATA-TEXT System.
2. Estimates of present and future demand for the traits measured by the variables, by linking occupational employment trends (as estimated by the BLS in *Tomorrow's Manpower Needs*) with characteristics of the individual occupations from the DOT-tape.

The Factor Analysis

The factor analysis (Table 2) of information on the DOT-tape was carried out for suggestive purposes, to get an idea of how variables group together as a possible guide for thinking about them in subsequent work. Since further numerical work was not planned on the basis of these results, a short-cut approach was used to identify the factors and to associate variables with them. Each variable was first associated with the factor on which it was most heavily loaded. Some changes were then made on intuitive grounds. For one thing, it was convenient to consider the five variables listed under "worker functions" and "training time" separately from the four factors. Likewise for those variables that are not heavily loaded on any factor.

The remaining variables are listed in Table 3 under four groups, given labels "Brains," "Brawn," "Crafts," and "Judgment," as a rough reflection of the kinds of variables that fall under each. Though the technical basis for these groupings and characterizations can be ques-

TABLE 1

Summary Description of Variables

(*"Page Ref." refers to Volume II of the *Dictionary of Occupational Titles*. The measures and nomenclature here conform to that work.)

VARIABLE NUMBER	SHORT NAME	DESCRIPTION	MEASURE	PAGE REF.*
(Worker Functions — Relationships to Data, People, Things)				
1	DATA	Worker's relationship to data	8 kinds	649
2	PEOPLE	Worker's relationship to people	9 kinds	649
3	THINGS	Worker's relationship to things	8 kinds	650
(Training Time)				
4	GEN ED DEV	General educational development	6 levels	652
5	SPECVOCPREP	Specific vocational preparation	9 levels	652
(Aptitudes)				
6	GENL INTEL	General learning ability	Segment of working population with level of aptitude needed for adequate performance of job.	653
7	VERBAL	Ability with words and ideas		
8	NUMERICAL	Ability with arithmetic		
9	SPATIAL	Comprehension of forms in space		
10	FORM PERCEP	Visual perception		
11	CLERICAL	Perception of written symbols		

TABLE 1 *(Continued)*

Summary Description of Variables

VARIABLE NUMBER	SHORT NAME	DESCRIPTION	MEASURE	PAGE REF.*
(Aptitudes, continued)				
12	MOTOR COORD	Ability to move accurately, quickly	Segment of working population with level of aptitude needed for adequate performance of job.	653
13	FINGER DEXT	Ability to manipulate small objects		
14	MANUAL DEXT	Skill with hands		
15	EYEHANDFOOT	Coordination of hands, feet, eyes		
16	COLOR DISCR	Perception of colors		
(Temperaments)				
17	CHANGE	Variety of duties; frequent change	Existence in occupation of situations to which worker must adjust.	654
18	REPETITION	Repetitive operations in set order		
19	NO INDEPEND	Action under specific instruction		
20	CONTROL	Planning and control of own activities		
21	DEAL W PEOPLE	Active relationship with people		
22	WORK ALONE	Working in physical isolation		
23	INFL PEOPLE	Influencing people's attitudes, judgments		
24	STRESS, RISKS	Good performance under stress, risk		
25	JUDG EVAL	Need for evaluation, decision through judgment		

TABLE 1 *(Continued)*

Summary Description of Variables

VARIABLE NUMBER	SHORT NAME	DESCRIPTION	MEASURE	PAGE REF.*
(Temperaments, continued)				
26	MEAS EVAL	Need for evaluation, decision based on measurement	Existence in occupation of situations to which worker must adjust.	654
27	PERS INTERP	Personal interpretation of feeling, ideas, facts		
28	PRECISION	Precise attainment of limits, standards		
(Physical Demands and Working Conditions)				
29	STRENGTH	Need to lift, carry, push, pull	5 levels	654
30	CLIMB, BAL	Need to climb or balance	Job requires or not.	655
31	STOOP, ETC.	Need to stoop, kneel, crouch, crawl		
32	REACH, TOUCH	Need to reach, handle, finger, feel		
33	TALK, HEAR	Need to express ideas verbally, or interpret sounds		
34	SEE	Need for various types of visual perception		
35	PLACE WHERE	Work inside, outside, or both	3 types	656
36	COLD	Extremes of cold or temperature changes	Existence of in job or not.	656
37	HEAT	Extremes of heat or temperature changes		
38	WET	Contact with liquids, high humidity		

TABLE 1 *(Continued)*

Summary Description of Variables

VARIABLE NUMBER	SHORT NAME	DESCRIPTION	MEASURE	PAGE REF.*
(Physical Demands and Working Conditions, continued)				
39	NOISE	High level of noise, vibration	Existence of in job or not.	656
40	HAZARDS	Definite risk of bodily injury		
41	FUMES	Exposure to fumes, odors, dust, etc.		

TABLE 2

Summary of Factor Analysis

Factor 1 (9.86)		*Factor 2 (4.80)*		*Factor 3 (2.93)*	
Variable	Loading	Variable	Loading	Variable	Loading
1 DATA	.91	2 PEOPLE	-.42	15 EYEHANDFOOT	.55
2 PEOPLE	.62	3 THINGS	.76	24 STRESS, RISKS	.32
4 GEN ED DEV	-.91	9 SPATIAL	.52	29 STRENGTH	-.50
5 SPECVOCPREP	-.89	10 FORM PERCEP	.54	30 CLIMB, BAL	.63
6 GEN INTEL	.86	12 MOTOR COORD	.58	31 STOOP, ETC.	.55
7 VERBAL	.86	13 FINGER DEXT	.56	35 PLACE WHERE	-.53
8 NUMERICAL	.80	14 MANUAL DEXT	.69	38 WET	.26
9 SPATIAL	.56	16 COLOR DISCR	.33	39 NOISE	.31
10 FORM PERCEP	.49	21 DEAL W PEOPLE	-.49	40 HAZARDS	.64
11 CLERICAL	.70	22 WORK ALONE	.12	41 FUMES	.38
17 CHANGE	.57	23 INFL PEOPLE	-.33		
18 REPETITION	-.79	26 MEAS EVAL	.36		
19 NO INDEPEND	-.64	28 PRECISION	.62		
20 CONTROL	.64	29 STRENGTH	-.32		
21 DEAL W PEOPLE	.61	32 REACH, TOUCH	.57		
25 JUDG EVAL	.40	33 TALK, HEAR	-.38		
26 MEAS EVAL	.53	34 SEE	.45		
29 STRENGTH	.36				
32 REACH, TOUCH	-.46				
33 TALK, HEAR	.66				

Factor 4 (1.52)

Variable	Loading
15 EYEHANDFOOT	.31
24 STRESS, RISKS	.32
25 JUDG EVAL	.41
26 MEAS EVAL	-.35
27 PERS INTERP	.46
35 PLACE WHERE	-.33
36 COLD	-.12
37 HEAT	-.31

Notes: Highest loadings and those of .31 or over in magnitude are listed for each variable.
Latent root is given next to each factor heading.
Variables are explained in Table 1.

TABLE 3

Summary of Manner of Treatment Here of the 41 Variables
(See Table 1 for definition and description of variables)

Variables that Will be Examined Individually:

1 DATA (See Table 4)
2 PEOPLE (See Table 5)
3 THINGS (See Table 6)
4 GEN ED DEV (See Table 7)
5 SPECVOCPREP (See Table 8)

Variables that Will be Considered Under Four Factor-related Groups:

Brains Group (See Table 9)	Crafts Group (See Table 10)	Brawn Group (See Table 11)
6 GENL INTEL	10 FORM PERCEP	15 EYEHANDFOOT
7 VERBAL	12 MOTOR COORD	29 STRENGTH
8 NUMERICAL	13 FINGER DEXT	30 CLIMB, BAL
9 SPATIAL	14 MANUAL DEXT	31 STOOP, ETC.
11 CLERICAL	28 PRECISION	35 PLACE WHERE
17 CHANGE	32 REACH, TOUCH	40 HAZARDS
18 REPETITION	34 SEE	41 FUMES
19 NO INDEPEND		
20 CONTROL		
21 DEAL W PEOPLE		
26 MEAS EVAL		
33 TALK, HEAR		

Judgment Group (See Table 12)
25 JUDG EVAL
27 PERS INTERP

TABLE 3 *(Continued)*

Summary of Manner of Treatment Here of the 41 Variables

Variables Not Assigned to any Group: (See Table 13)

16	COLOR DISCR	36	COLD
22	WORK ALONE	37	HEAT
23	INFL PEOPLE	38	WET
24	STRESS, RISKS	39	NOISE

tioned, they fit fairly well both with the results on which they are based, and with conventional notions of human traits. Further, since none of the subsequent results will be given a form that could not readily be regrouped, there seems no harm in using these four headings.

Forecast of Worker Functions

In Tables 4, 5, and 6 estimates for 1960 and projections for 1975 are given for the DOT's "worker functions" in relationship to data, people, and things (variables 1, 2, and 3 in the terminology of this paper). Changes in the distribution of these relationships from 1960 to 1975 suggest changes in the emphasis and complexity of work required of the labor force.

These tables and those which follow have the same simple format. Fractions of the work force rather than numbers of workers are used. They are based on a total labor force of 66,370,300 in 1960 and 88,365,100 in 1975. (These figures differ slightly from those of TMN because of round-off and key punch errors and slight tape inconsistencies.) Thus, for example, 1.9 percent of workers in 1960, or 1,266,200, and 2.5 percent in 1975, or 2,199,400, "synthesize" data. The third column gives the rate of growth of employment in the category over the total period 1960 to 1975. The growth of 74 percent for synthesizing is derived by dividing 2,199,400 workers in 1975 by 1,266,200 workers in 1960. The last column gives a clearer picture of relative growth of the several categories by showing growth rate as a multiple of growth of the labor force as a whole. Since the labor force is forecast to grow 33 percent from 1960 to 1975, we divide 74 percent by 33 percent to establish that the number of workers who "synthesize" data will increase at a rate 2.2 times that of the whole labor force.

Table 4 shows that in 1960, 61.2 percent of all workers had some significant relationship to data, most of these in "coordinating," "analyzing," or "compiling." By 1975, 64.9 percent of all workers will have significant relationships to data. All the relationships to data except the lowest, that of "comparing," grow more rapidly than the labor force itself. The results of this table can be interpreted in terms of occupational change. Although no specific investigation has been made, we can assume that "synthesizing" is related to professional jobs, and

"computing" and "copying" to clerical jobs. The table as a whole reveals the growing complexity of worker functions in relation to data, especially at the highest level. Interpretations of this sort are possible throughout the tables.

TABLE 4

Estimates of Demand for Relationships to Data

	Employment as Fraction of:		*Growth in Employment, 1960-75:*	
RELATIONSHIP	1960 Workforce	1975 Workforce	As Fraction of 1960 Number	As Multiple of Growth in Workforce
Synthesizing	.019	.025	.74	2.2
Coordinating	.226	.229	.35	1.05
Analyzing	.115	.125	.45	1.35
Compiling	.172	.185	.43	1.3
Computing	.029	.032	.48	1.5
Copying	.031	.035	.48	1.5
Comparing	.019	.018	.23	0.7
No relationship	.388	.351	.21	0.6

Table 5 (relationship to people) shows 41.1 percent of workers in 1960 with significant relationships to people. By 1975, 43.5 percent will deal with people. "Diverting" illustrates the most rapid growth. (The percentages for 1960 and 1975 mask the actual change, which is from 238,400 in 1960 to 377,500 in 1975.) This corroborates the expected increase in leisure time, since the artists, entertainers, and sports figures fall in this category. The growth of the first category, "mentoring," compares with that of "synthesizing" data and must relate to professional jobs. In contrast with the data table, the "lower" relationships to people, especially "serving," grow rapidly.

In Table 6, 53.7 percent of all workers in 1960 have significant relationships to things, with most of them in "precision-working" (probably based on craftsmen) and "handling" (based on laborers). By 1975 workers with relationships to things decline to 49.5 percent. But "precision-working" grows at a rate 1.1 times national growth, while two other complex relationships, "setting-up" and "operating, controlling," grow nearly as rapidly or as rapidly as national growth. Thus,

TABLE 5

Estimates of Demand for Relationships to People

RELATIONSHIP	*Employment as Fraction of:* 1960 Workforce	1975 Workforce	*Growth in Employment, 1960-75:* As Fraction of 1960 Number	As Multiple of Growth in Workforce
Mentoring	.011	.012	.53	1.6
Negotiating	.033	.035	.45	1.4
Instructing	.029	.032	.46	1.4
Supervising	.067	.068	.34	1.05
Diverting	.004	.004	.58	1.8
Persuading	.058	.058	.33	1.0
Speaking, Signaling	.143	.152	.42	1.3
Serving	.067	.074	.47	1.4
No Relationship	.589	.565	.27	0.8

TABLE 6

Estimates of Demand for Relationships to Things

RELATIONSHIP	*Employment as Fraction of:* 1960 Workforce	1975 Workforce	*Growth in Employment, 1960-75:* As Fraction of 1960 Number	As Multiple of Growth in Workforce
Setting up	.016	.015	.29	0.9
Precision Working	.148	.153	.37	1.1
Operating, Controlling	.050	.050	.33	1.0
Driving, Operating	.036	.033	.23	0.7
Manipulating	.068	.058	.13	0.4
Tending	.051	.046	.21	0.6
Feeding, Offbearing	.008	.007	.18	0.5
Handling	.159	.133	.12	0.4
No Relationship	.463	.505	.45	1.35

the overall drop in relationships to things masks a growth in complex functions and a substantial decline in the lower levels. The decline in functions related to things does not equal the combined growth of relationships to data and people. In 1975 workers will be more likely to have to deal with more than one of the three worker functions and at somewhat higher levels than before.

Training Time

From the evidence concerning job functions, we would expect training requirements for workers to grow. These changes are measured in the DOT by ratings for "general educational development" (GEN ED DEV) and "specific vocational preparation" (SPECVOCPREP). GEN ED DEV is not defined by years of schooling, but by a scale based on "reasoning development," "mathematical development," and "language development." Thus, it is not readily interpretable in terms of formal schooling. But this lack of precise scholastic meaning does not obscure the message suggested by the forecasted trends in this variable, shown in Table 7.

"Specific vocational preparation" also reflects multiple dimensions. It is based on a combination of vocational education, apprentice training, in-plant training, on-the-job training, and essential experience in other jobs. This mixture makes it difficult to interpret the trends indi-

TABLE 7

Estimates of Demand for General Educational Development

	Employment as Fraction of:		*Growth in Employment, 1960-75:*	
LEVEL	1960 Workforce	1975 Workforce	As Fraction of 1960 Number	As Multiple of Growth in Workforce
Level 1 (low)	.043	.033	.04	0.1
Level 2	.205	.178	.17	0.5
Level 3	.298	.309	.375	1.15
Level 4	.277	.282	.34	1.0
Level 5	.143	.156	.46	1.4
Level 6 (high)	.035	.042	.63	1.9

Note: See *Dictionary of Occupational Titles*, Vol. II, p. 652, for definition of levels.

cated in Table 8, and to relate them to other factors. But the general nature of changes of SPECVOCPREP reveals the same pattern as that of GEN ED DEV. The 1960 work force had to have a broad spectrum of vocational preparation, with 19.9 percent requiring only 30 days' or less preparation, but with 30.7 percent needing over two years' preparation. The 1975 distribution reveals a continual upgrading of requirements, with the greatest relative increases accounted for by the highest levels of training.

Even though both GEN ED DEV and SPECVOCPREP are not uni-dimensional measures, they reveal a general expectation of educational upgrading, coming directly from work requirements as defined by the DOT. This upgrading must come primarily from formal schooling of young people who will newly enter the labor force. While many retraining programs for adults have recently been initiated, most older workers have in fact already completed their basic education and training.

TABLE 8

Estimates of Demand for Specific Vocational Preparation

	Employment as Fraction of:		*Growth in Employment, 1960-75:*	
LEVEL	1960 Workforce	1975 Workforce	As Fraction of 1960 Number	As Multiple of Growth in Workforce
Level 1 (Short Demonstration Only)	.021	.017	.06	0.2
Level 2	.178	.164	.22	0.7
Level 3	.141	.136	.28	0.8
Level 4	.106	.104	.30	0.9
Level 5	.100	.103	.37	1.1
Level 6	.147	.153	.40	1.2
Level 7	.193	.197	.35	1.05
Level 8	.108	.119	.47	1.4
Level 9 (More than 10 Years)	.006	.007	.61	1.8

Note: See *Dictionary of Occupational Titles*, Vol. II, p. 653, for explanation of levels of vocational preparation.

Forecasts of Other Worker Traits

The characteristics shown by the five variables forecast in some detail above indicate the form and content that can generally be expected from the other variables. These can be sliced, patched, and arranged in a variety of ways. In the following tables they will be grouped as suggested earlier (Table 3). As was seen then, the "Brains Group" gets a lion's share of the variables from the factor analysis, even after worker functions and training time are removed from the listing and treated separately (above). This group brings together a set of variables that are forecast to grow (Table 9) substantially faster than the labor force over the coming years. Even the two declining variables (REPETITION and NO INDEPEND) reflect qual-

TABLE 9

Estimates of Demand for Variables in the "Brains" Group

	Employment as Fraction of:		*Growth in Employment, 1960-75:*	
	1960 Workforce	1975 Workforce	As Fraction of 1960 Number	As Multiple of Growth in Workforce
APTITUDES (Corresponding to upper third of workforce)				
6 GENL INTEL	.254	.280	.48	1.5
7 VERBAL	.240	.264	.47	1.5
8 NUMERICAL	.127	.146	.53	1.6
9 SPATIAL	.094	.105	.49	1.55
11 CLERICAL	.087	.102	.54	1.65
TEMPERAMENTS (Existence in job of situations requiring)				
17 CHANGE	.337	.344	.36	1.1
18 REPETITION	.375	.354	.26	0.8
19 NO INDEPEND	.279	.256	.22	0.6
20 CONTROL	.199	.208	.36	1.1
21 DEAL W PEOPLE	.389	.412	.415	1.25
26 MEAS EVAL	.307	.318	.375	1.15
PHYSICAL DEMANDS AND WORKING CONDITIONS (presence of in job)				
33 TALK, HEAR	.425	.456	.425	1.3

Note: See Table 3 for description of the grouping of variables.

ities complementary to CHANGE and CONTROL, which show growth. This group of variables, therefore, is in high and growing demand. We might worry over specifics here as elsewhere, but shall not; the general message is preponderantly clear. Anything important to be said about it — pro and con — will spring from larger issues, not from specifics.

Likewise the "Crafts Group" exhibits (Table 10) substantial growth of many of its variables. Here, as in Table 9, we note certain characteristics which are in relatively low absolute demand, but which are growing rapidly. These may suggest fields of activity that are "comers" and which thus may have implications for policy makers, particularly in education and training. Table 10 suggests strongly that the need for workers with high levels of physical skill is far from being on the decline. It would be interesting to know how this effect works in combination with needs for training and with variables in the "brains group," but this has not been explored. Generally, a high

TABLE 10

Estimates of Demand for Variables in the "Crafts" Group

		Employment as Fraction of:		*Growth in Employment, 1960-75:*	
		1960 Workforce	1975 Workforce	As Fraction of 1960 Number	As Multiple of Growth in Workforce
APTITUDES (Corresponding to upper third of workforce)					
10	FORM PERCEP	.106	.122	.52	1.65
12	MOTOR COORD	.050	.060	.60	1.8
13	FINGER DEXT	.056	.064	.55	1.65
14	MANUAL DEXT	.049	.054	.44	1.3
TEMPERAMENTS (Existence in job of situations requiring)					
28	PRECISION	.347	.357	.37	1.1
PHYSICAL DEMANDS AND WORKING CONDITIONS (Presence of in job)					
32	REACH, TOUCH	.763	.753	.32	0.95
34	SEE	.395	.414	.38	1.15

Note: See Table 3 for a description of the grouping of variables.

degree of correlation among requirements is to be expected, reflecting the complexity of worklife that underlies these growing demands.

Thirdly, the "Brawn Group" (Table 11) shows a mixture of forecasts. There is a decline in demand for physical requirements generally. The increase in EYEHANDFOOT may or may not be associated with complexity of work, or with increases identified in the other groups. The information available from the study reported here is not enough to determine that. The increase in PLACE WHERE heralds a corresponding decrease in outdoor work, which might be aligned conceptually with the general decrease in the physical requirements of the "Brawn Group."

A small but interesting set of variables is the "Judgment Group" (Table 12). This appears from the factor analysis to represent a distinct and growing kind of requirement, present in a minority of jobs, but, perhaps, coming on fast. It seems a natural addition to "Brains, Brawn" and "Crafts," and is suggestive of further study.

TABLE 11

Estimates of Demand for Variables in the "Brawn" Group

		Employment as Fraction of:		*Growth in Employment, 1960-75:*	
		1960 Workforce	1975 Workforce	As Fraction of 1960 Number	As Multiple of Growth in Workforce
APTITUDES (Corresponding to upper third of workforce)					
15	EYEHANDFOOT	.006	.007	.35	1.1
PHYSICAL DEMANDS AND WORKING CONDITIONS					
				(Presence of in job)	
29	STRENGTH*	.312	.285	.23	0.7
30	CLIMB, BAL	.114	.098	.15	0.45
31	STOOP, ETC.	.204	.187	.21	0.65
35	PLACE WHERE**	.738	.770	.39	1.2
40	HAZARDS	.128	.120	.255	0.75
41	FUMES	.076	.074	.29	0.9

Notes: * Need to manipulate loads of 20 lb. or more
** Work exclusively indoors
See Table 3 for description of the grouping of variables.

Finally, in Table 13, those variables that did not make it into the earlier discussion are included for completeness, and are presented without further comment.

TABLE 12

Estimates of Demand for Variables in the "Judgment" Group

		Employment as Fraction of:		*Growth in Employment, 1960-75:*	
		1960 Workforce	1975 Workforce	As Fraction of 1960 Number	As Multiple of Growth in Workforce
TEMPERAMENTS (Existence in job of situations requiring)					
25	JUDG EVAL	.198	.206	.38	1.15
27	PERS INTERP	.020	.024	.58	1.75

Note: See Table 3 for description of the grouping of variables.

TABLE 13

Estimates of Demand for Other (Unassigned) Variables

		Employment as Fraction of:		*Growth in Employment, 1960-75:*	
		1960 Workforce	1975 Workforce	As Fraction of 1960 Number	As Multiple of Growth in Workforce
APTITUDES (Corresponding to upper third of workforce)					
16	COLOR DISCR	.016	.017	.37	1.1
TEMPERAMENTS (Existence in job of situations requiring)					
22	WORK ALONE	.004	.003	(Decreasing)	
23	INFL PEOPLE	.095	.098	.375	1.15
24	STRESS, RISKS	.026	.028	.42	1.25
PHYSICAL DEMANDS AND WORKING CONDITIONS (Presence of in job)					
36	COLD	.007	.007	.33	1.0
37	HEAT	.028	.029	.39	1.2
38	WET	.057	.046	.07	0.2
39	NOISE	.106	.102	.265	0.8

Note: See Table 3 for description of the grouping of variables.

Some Further Comments on Aptitudes

The requirements for aptitudes, being the most firmly rooted in measurement of the working population, deserve some additional comment, particularly with regard to requirements for workers with high aptitudes. The ratings for aptitudes in the DOT are based on the General Aptitude Test Battery (GATB), standard tests developed by the Bureau of Employment Security over many years to measure the abilities related to success in different occupations. The BES gives the GATB to 35 or more workers in a particular occupation, establishes independent measures of individual success in the occupation, and then produces a "cutting score" for key aptitudes. If a potential worker scores below these scores, he is not expected to achieve success in the job. By 1966 GATB norms for almost 400 jobs had been published. The BES is continually testing more workers and publishing more scores. The base population for evaluating the test results is the employed labor force in the age range 18-54 from the 1940 *Census of Population*. Since the GATB is available for only a few hundred jobs, the DOT ratings are based on a system of estimated minimum levels for average success on jobs:

Level 1 — requires the skills possessed by the top 10 percent of the working population.
Level 2 — requires the skills possessed by the top 10 to 33.3 percent of the working population.
Level 3 — requires the skills possessed by the middle 33.3 percent of the working population.
Level 4 — requires the skills possessed by the lowest 10 to 33.3 percent of the working population.
Level 5 — requires the skills possessed by the lowest 10 percent of the working population.

But the lowest level, level 5, does not really define aptitudes possessed by the lowest 10 percent of the population, even though Volume II states that it does. The training manual for job analysts explains (Reference 14):

> When the present method of rating was devised it was desired that the rating that would reflect the amount possessed by the lowest third of the population be a positive decision on the part of the rater, thus eliminating guesswork in subsequent

evaluation of the ratings. For those situations where the rater actually could not see the aptitude through lack of information in the definition or where the rater could see it only in a negligible amount the level 5 rating was provided. Thus the "5" ratings protect the meaningfulness of the "4" ratings. The "5" rating is a sort of residual rating. It is to be used when there can be no positive decision about level 4.

The Squeeze on Intelligence

In 1960 the number of jobs available for persons at the top levels of intelligence was somewhat less than the number of these persons in the working population. 6.3 percent of all jobs required the intelligence of the top 10 percent of the population, while 25.4 percent of all jobs required intelligence in the top 33.3 percent. Thus many persons of these levels work at jobs which do not call upon their intelligence completely, and high intelligence jobs are more than likely filled by qualified persons. But this assumes a good fit between persons and jobs. Many highly intelligent persons may be unfit for these jobs for educational, psychological, or other reasons. Thus the 1960 data may already represent pressure on the available intellectual resources of the population.

While the implications at high levels of general intelligence are uncertain, those for Levels 4 and 5 are clear. The absence of Level 5 jobs is, as noted above, a peculiarity of the coding system. But only 25.3 percent of all jobs require the intelligence of the lowest 33.3 percent of the population. *If we accept the data,* 8 percent of the working population are persons of low intelligence, who are either unemployed or in jobs which require intelligence greater than their capacity. Put another way, 24 percent of workers of low intelligence must work in jobs requiring at least middle level intelligence, if they work at all. There are, of course, ways to nullify or rationalize this suggestion, but it should not be abandoned summarily.

By 1975 demands for persons of high intelligence are forecast to grow, while there is further proportional reduction of jobs for those with low general intelligence. The number of jobs for those in the top 33.3 percent of the population moves closer to the limits of the availability of these persons, with 28.0 percent of all jobs requiring the intelligence present in the top third of the workforce. Meanwhile 11

percent of the working population, or a full one third of low intelligence persons, would find their intelligence inadequate.

In 1975 verbal ability also comes close to putting a "squeeze" on persons with low aptitudes, showing a difference of only one half a percent. Jobs for all low aptitudes except manual dexterity and eye-hand-foot coordination have a relative decrease or remain stable.

A consistently high growth in demand is forecast (Table 14) for aptitudes corresponding to the upper tenth of the workforce. In many cases the demand for these high-level aptitudes is low, but in almost all cases they are growing rapidly. (Exception is MOTOR COORD, which for some reason has been identified as necessary to a negligible number of workers, probably a vagary of the underlying data and method.) This tendency is particularly striking for GENL INTEL and VERBAL, which are in relatively high absolute demand, and also growing rapidly. This suggests (or rather confirms a prior belief) that in coming years it will be even more important to utilize these resources with particular care.

TABLE 14

Estimates of Demand for High Level Aptitudes
(Corresponding to upper tenth of workforce)

		Employment as Fraction of:		*Growth in Employment, 1960-75:*	
		1960 Workforce	1975 Workforce	As Fraction of 1960 Number	As Multiple of Growth in Workforce
6	GENL INTEL	.063	.075	.59	1.8
7	VERBAL	.055	.066	.61	1.85
8	NUMERICAL	.027	.032	.58	1.8
9	SPATIAL	.011	.014	.66	2.0
10	FORM PERCEP	.005	.007	.66	2.0
11	CLERICAL	.003	.004	.54	1.6
12	MOTOR COORD°	.000	.000	.00	0.0
13	FINGER DEXT	.003	.003	.62	1.9
14	MANUAL DEXT	.002	.003	.56	1.7
15	EYEHANDFOOT	.000	.001	.64	1.9
16	COLOR DISCR	.001	.001	.51	1.5

° Only 2200 Workers in either year were identified by this analysis as needing MOTOR COORD at this level. This is clearly open to question.

Combinations of Aptitudes

Some analysis was also done with regard to demand for aptitudes in combination. A few of their salient points are indicated below. In 1960, 61 percent of workers did not need to have any aptitude in the top 33.3 percent of the workforce. The most important combinations of high aptitudes were those involving intelligence or verbal ability. Of the 13 commonest combinations, seven required intelligence and seven required verbal ability. By 1975, only 57.5 percent of workers are forecast to get along without any high aptitude. Combinations of *many* high aptitudes grow particularly rapidly. Combinations involving intelligence are particularly revealing. Need for intelligence by itself (i.e., not in combination with other aptitudes) grows at a rate of .9 of national growth, but combinations including intelligence grow in ascending order as the combinations become more complex, until the highest rates of growth (1.9 and 2.2 times national growth) are achieved by combinations of four and five aptitudes linked with intelligence. The data suggest that needs for *specialized* aptitudes are less important than needs for all-around persons. It would be interesting to know the distribution of aptitude combinations in the general working population, in order to suggest where there may be "squeezes" on combinations of aptitudes.

Some General Observations and Implications

The results presented above suggest a range of commentary, from quite specific criticisms to general impressions of their validity and usefulness. We shall suggest here some of the latter.

It is important to recall that this work projects demand for characteristics associated with jobs, not demand for the jobs themselves. The focus is thus not so much on the labor market as on the personal and educational implications of its trends. This puts in more fundamental terms than before the shape of the future as reflected by some of the demands placed on the workforce.

Also, the projections given here are of requirements placed on the workforce, not of its actual characteristics. In many instances, actual workers will be overqualified in certain respects; and in some they may fall short of presumed requirements.

Further, it is important to note that the method of projection neces-

sarily assumes no change in requirements of individual jobs between 1960 and 1975. The failing was not avoidable, but should be taken into account in interpretation of the results.

It is at once comforting and troubling that the results here confirm our general prejudices about future demands on the workforce. Comforting in that the general agreement tends to improve confidence both in the prejudices and in these results. Troubling in that there is a possibility of having fallen prey to circular argument, since the results, though gotten from an elaborate sequence of technical operations, rest in large part on subjective judgments very similar to these they confirm. But this is a pitfall of any such attempt to forecast. The results are at least consistent among themselves, and to a large degree with prior expectations.

Forecasts of this kind, in that they might influence policy, could become self-fulfilling — or self-denying — prophecies, depending on whether their implications are seen as desirable or not by those who make policy. Similarly, it is not surprising that demands made on the labor force tend usually not to violate the supply. Work is done by people, and therefore in some sense is made to be done by them. Ways of making work more productive and palatable are surely worth seeking, but they are subject to constraint by the aptitudes, temperaments, and other characteristics of the population that will do the work.

It is not uncommon in the above results to find rapidly growing demands based on a very small part of the workforce. In these cases, we might think that the demand implied by the growth is small. But it is greater than it looks, since it will usually not be met proportionally throughout the workforce, but primarily by new entrants. When this is the case, severe demands on facilities for education and training may be implied.

One intent of this research has been to extract from the data some information that might be of use in making decisions or setting policies. We believe the results reported here do have potential value for that purpose. But it is not for us to specify or suggest conclusions for several reasons: 1) such use will depend on what other information is available; 2) it will depend on the context and intent of the decision or policy; and 3) the effect of this information will vary with the confidence attached to it by whoever uses it. So it behooves us not to draw conclusions, but to suggest a few things that should be borne in mind when doing so.

Conclusions can be drawn and actions taken at several levels, including those which will be described here as *societal, industrial, educational,* and *personal.* At each of these there are different possibilities, purposes, and constraints. To each, forecasts of requirements for skills in the labor force can have useful meaning. At the societal level, this would include broad questions of social policy, equality of opportunity, and compensatory programs. At the industrial level, modifications to exploit characteristics in less short supply is a possibility. For education, plans for intensity, scope, and distribution of training ought to take these forecasts into account. Finally, at the personal level, individuals might use information of this kind in their decisions to invest time and money in education and career development, alloting their efforts in the face of the priorities (and hence also the rewards) inherent in the demands on the workforce.

In the first three of the above levels — societal, industrial, educational — there is a need (frequently neglected) to take into account all of the working population. There has been noted here a growing pressure, particularly in terms of intellectual talents and skills, on both the most and least qualified portions of the workforce. When these pressures can be adjusted by training, suitable programs might be designed and carried out. When they relate to traits not easily modified, there is a need to efficiently utilize the talented, and to modify the content of work to allow the poorly endowed to take an active and useful part. Thus there is a need to adapt the work situation to people as well as people to it. This is not a new or novel requirement, but it is too often forgotten. The results here tend to re-emphasize it once more.

About Accuracy

We now come to the question of the degree of confidence that may be placed on the results given in this paper. It makes little sense to speak of them as being "right" or "wrong." Pretty clearly there is some truth in them. Likewise, all are surely subject to inaccuracy. Rather than give any firm estimate of overall accuracy, we must be content to list the principal sources of question, and to evaluate each briefly.

1. The DOT is sometimes criticized both for its choice of information and for the accuracy of its contents. But its failings are fre-

quently those of omission, or of detail. Whatever faults it may have, the DOT is a monumental work whose overall contents are highly useful. Our need here was for a comprehensive source that we could rely upon in a general way. The DOT is unique in this respect.

2. General questions of choice of variables, accuracy of data, and currency of data can arise. As to the first, we used all those variables available to us on the DOT tape. As to accuracy and currency, we hope this may be improved in information sources of the future; but for now we chose to work energetically (though not uncritically) with what is available.
3. It is important to distinguish the DOT and the DOT-tape used here. The former, a three volume publication, contains specification of "worker traits" for 114 groupings of occupational titles. These were developed using judgment as well as measured data. The DOT-tape is essentially the raw material for the DOT, as drawn from the field. It is thus in somewhat less refined form than the DOT itself.
4. The projections of employment as taken from TMN are also subject to question. But so are any projections or forecasts. Real prediction of the future is impossible and must remain so. The TMN projections were carefully created from present information, trends, and understanding. They are as likely as any to remain reasonably correct in most of their essentials.
5. Definitions and specifications of jobs are likely to change. This is so more of some jobs than of others. Here again we can only conjecture that most of the information used will remain reasonably true within the near future. So long as the bulk of the cases do not vary unduly, the effect of such error should be mild.
6. There are spots where the results indicate, or come close to indicating, that the demands on the labor force are technically impossible to fill. Clearly, something has to give in these cases. Either the requirements are in some cases too strict; or some jobs are filled by inadequate workers; or the definition of certain occupations are in fact altered to suit circumstances; or unemployment is severe among workers of low qualifications. The truth is no doubt a combination of all of these.
7. The composition of the working population changes over time, as can be seen from the Census. By 1975 we can expect more

women in the labor force and fewer young people, because they will still be in school. There has also been a general rise in scores on intelligence tests over the last fifty years. This is likely to continue to 1975. Both of these changes have also been in effect since data for the DOT was first gathered ten years ago.

8. Computational errors are also a possibility. The general intuitive acceptability and consistency of the results suggests this did not happen on a wide scale. In some cases, such errors have been detected, and compensating adjustments have been made in the results. An informal survey of the magnitude of known errors that cannot be readily compensated for (i.e., where information is known to have been lost in the computer analysis) shows that the fractions of employment given in the several tables could be off as much as .005, if the data were very malevolently distributed. There is neither reason to believe this is the case, nor guarantee that it is not.
9. Our method of distribution of DOT titles within the occupational groups of TMN has some effect on results. This can be estimated by experiment, as is described and demonstrated in an appendix to this paper.
10. The assignment of titles from the DOT to the groups forecast by TMN was made with an eye to speed and convenience. When a careful and detailed translation is available, a repetition of this work would be desirable.

By and large, however, we believe that the bulk of the data evens out its vagaries. This is one of the advantages of treating with skills over a full range of occupations, not for individual occupations or groups of occupations.

Appendices on Method

We give below a brief picture of the technical procedures used to obtain the results described in this paper. This will be done in three parts:

1. Translation betwen the two major sources of information, the job titles of the DOT-tape, and the 161 occupational groups of TMN.
2. Distribution of characteristics of individual titles among the total number of workers assigned to the occupational groups.
3. Some alternative distributions, to get an idea of how sensitive the results are to the distribution of specific job titles within the several occupational groups.

APPENDIX 1 — TRANSLATION

Tomorrow's Manpower Needs was available to us in draft from the Bureau of Labor Statistics. It contains a matrix of employment for 161 occupational categories by over 100 industries and industry groups for 1960; and similar projections to 1975. The 1960 distributions of employment are derived from the *1960 Census of Population*, from the Bureau of Labor Statistics *Monthly Report on the Labor Force*, from various agencies, and from estimates prepared by the BLS. The 1975 projections of employment were developed by BLS economists, who extrapolated past trends according to several mathematical models, and then adjusted the results according to expected market conditions, and technological and other changes.

This paper uses only the data on occupations. The 161 categories in TMN are an adaptation of the *1960 Census of Population* categories, with some of the more exotic titles aggregated into "not elsewhere classified" categories (e.g., hucksters, newsboys, furriers, fruit, nut and vegetable graders), and with other titles added.

The DOT is even more massive than TMN. Compiled by the Bureau of Employment Security over ten years to aid placement efforts of employment and vocational counselors, it defines 21,741 separate occupations. The DOT consists of three volumes. Volume I contains

an alphabetic listing of jobs, with definitions of the work performed in each. Volume II contains listings of jobs according to several different criteria. It also defines abilities, traits, and other characteristics rated for each job, which are the following:

1. Relationships to data, people, and things
2. Training time
3. Aptitudes
4. Interests
5. Temperaments
6. Physical demands
7. Working conditions

These traits form the basic parameters for our skill projections. The Supplement to the DOT, the third published volume, rates physical demands, working conditions, and training time for each job.

The research of this paper uses a magnetic tape provided by the Bureau of Employment Security, containing ratings for 13,777 jobs of six of the seven dimensions noted above. Many of the 21,741 occupations — the "undefined related titles" described on page xxi of DOT Volume I — were considered so similar to other occupations that they were not rated separately. Also, "interests" were not available for inclusion on the tape.

It would seem easy to combine the nearly 14,000 jobs of the DOT-tape, each with their ratings of skills and duties, and the 161 occupational groups of TMN, with their employment figures for 1960 and 1975. But the two documents were developed separately for different purposes. Thus their classification systems are not entirely compatible. A translation between them is needed.

The problem is how to link the jobs without making 14,000 observations and decisions. The procedure used in response to this problem is based on the six digit DOT number. The first three digits of this number define the materials, products, or subject matter of the work described, and are listed on pages 3-24 of Volume II of the DOT. Digits four to six define the type and complexity of the worker's relationships to data, people, and things in the job (the worker functions referred to in this paper). The six digit number does not define each job uniquely — in some cases more than 100 jobs have the same DOT number.

The procedure for translation used in this paper is as follows:

1. Look at the first three digits of the DOT number, the 603 categories related to materials, products, or subject matter of the job, and when possible, relate all jobs with the same number to one TMN occupational group. Examples:

TMN: electrical engineer	DOT digits 1-3: 003 (electrical engineering). (All jobs with DOT digits 1-3 of 003 are classified here under TMN "electrical engineer.")
TMN: postal clerks	DOT digits 1-3: 231 (mail clerks) and 232 (post office clerks).

2. If the three digit DOT number can be divided among several TMN categories, use the entire six digit number to classify DOT jobs. Example:

TMN: insurance agent	DOT digits 1-6: 250.258.
TMN: real estate agent	DOT digits 1-6: 250.358.

3. Since the six digit DOT number does not usually define a single job, sometimes the DOT number itself straddles two TMN categories. In this case, examine and classify individual jobs. This is avoided unless absolutely necessary. Example:

TMN: postmasters	DOT digits 1-6: 188.168: postmaster. (Other jobs with DOT digits 1-6: 188.168 are assigned elsewhere.)
TMN: counter and fountain workers	DOT digits 1-6: 311.878: cafeteria counterman; and DOT digits 1-6: 311.878: lunchroom and coffeeshop counterman. (Other jobs with DOT digits 1-6: 311.878 are assigned elsewhere.)

Among blue collar jobs (DOT jobs with digits 1-3 of 500 to 999) a fourth method is necessary because of incompatibilities much more severe than those in professional or clerical jobs. For instance, TMN has a category "construction carpenters," but the DOT category of "carpenters and related occupations" (DOT digits 1-3: 860) contains,

among others, carpenter foremen, streetcar carpenters, apprentice carpenters, rough carpenters, form builder helpers, and carpentry laborers. Not all of the jobs belong under TMN "construction carpenters," since a carpenter foreman belongs in the category of "foreman," a form builder helper in the category of "operatives not elsewhere classified," and a carpentry laborer in the category of "laborers."

These and other examples show that three categories of blue collar workers — laborers, foremen, and inspectors — systematically cut across the first three digits of the DOT number, and depend instead on the last three digits, those defining the type and complexity of worker relationships to data, people, and things. Thus if any blue collar job had one of the following sets of DOT digits 4-6, it was assigned to the appropriate laborers, foremen, or inspectors category before applying the regular methods of classification:

TMN: laborers	DOT digits 4-6: 887
TMN: foremen	DOT digits 4-6: 130, 131, 132, 133, 134, 137, 138
TMN: inspectors	DOT digits 4-6: 382, 384, 387, 484, 487

In some other cases the last three digits were also used to insure assignment of semi-skilled jobs into the operatives category and high skilled jobs into the craftsmen category.

The reader will appreciate the difficulties in choosing criteria by trying a few classifications himself. The system developed here is the product of long acquaintance of one of the authors with both documents and a determined, somewhat grueling effort at objectivity. This conversion is less reliable than that forthcoming from the Bureau of Employment Security, which is taking several years to complete. But it is structured and consistent, based on about 1000 decisions, and should not be far off the BES result.

The resulting distribution of DOT jobs among the nine major Census occupational groups is as follows:

Occupational Group	Number of Job Titles	Percent of Total	Percent of Titles as Multiple of Percent of Labor Force in Occupational Group, 1960
Professional	1254	9.1	.8
Managerial	526	3.8	.3
Clerical	681	5.0	.3
Sales	257	1.9	.3
Craftsmen	2314	16.8	1.3
Operatives	6467	47.0	2.6
Service	435	3.2	.3
Laborers	1519	11.0	2.0
Farm	302	2.2	.3
TOTAL	13755	100.0	

The fourth column of the table shows the extent to which an occupational group is over- or under-represented in the DOT compared to its distribution in the labor force in 1960. The DOT over-represents operatives, craftsmen, and laborers, but especially operatives. Jobs in these three groups may possibly be more differentiated *in fact* than professional or managerial jobs, but a more likely explanation is that the Bureau of Employment Security has traditionally dealt with and placed workers in these jobs rather than in non-factory jobs. The apparent over-representation may also be caused by the fact that industrial organizations tend to classify jobs and job duties strictly.

APPENDIX 2 — DISTRIBUTION

The assignment of DOT jobs to the categories of TMN is the prelude to a simple computer program that estimates distribution of skills and other characteristics in 1960 and 1975. This is based on three key assumptions. The first is that the ratings in the DOT are not biased. Since the ratings for each job are based on observations of workers by trained coders, we cannot be certain whether the coders systematically exaggerated or downgraded job requirements.

The second assumption is that requirements and duties for individual jobs will remain constant from 1960 to 1975. Historical analyses show that educational requirements for individual jobs have changed over time. It is also certain that actual skills and duties for some jobs

have changed. The data do not allow us to take these changes into account.

The third assumption can be seen from an example. Sixteen DOT jobs fall into the TMN category of "accountants and auditors." But we do not know the distribution of employment in these 16 jobs, which include accountants, auditors, bursars, estimators, credit analysts, and others. In this example, these 16 jobs have very similar skill and attitude ratings; thus the results are not greatly affected by which jobs have the most workers. The problem is more serious in, say, the 91 DOT jobs under the TMN category of "professional and technical workers, not elsewhere classified," where the skill and attitude ratings are dissimilar.

The tables of this paper are based on a simple, arbitrary solution, in which each DOT job within a TMN category is considered to have the same number of workers as do other jobs in the same category. Thus each of the 16 jobs assigned to "accountants and auditors" is assumed to have 429,332 divided by 16, or 26,833 workers. This method clearly adds uncertainty to the results.

These three assumptions, joined with the inevitable uncertainties of projection of employment requirements, mean that the resulting distributions of skills and attitudes in the labor force are only distant approximations of reality. Except for the third assumption, we cannot even measure the margin of error.

APPENDIX 3 — ALTERNATE DISTRIBUTIONS

As noted above, the distribution of DOT jobs *within* the occupational groups of TMN is not known. In the main text we assume that each job has a number of workers in it equal to that of each other job within the same occupational group. This may distort the distribution so that the numbers in either more complex jobs or less complex jobs are exaggerated, thus resulting in changed estimates of educational, intellectual, psychological, and physical requirements.

To examine the extent of this error, the effect of high and then low skilled jobs can be systematically exaggerated. The worker functions — relationships to data, people, and things — describe the relative complexity of jobs and are arranged in a rough hierarchy. Thus one of these relationships can be upgraded or downgraded, and the resulting changes in worker requirements analyzed. The relationship

to data was used for this purpose because more workers in 1960 have significant relationships to data than to people or things, and because the categories in relation to data have a more clear cut hierarchical order than those in relation to people and things. Four methods of distributing workers among jobs are described below:

1. "Equal Weighting." This is the method used in the text, and described in Appendix 2.

2. "Upgrade data." Here it was assumed that within any TMN occupational group, each job occurs 1.5 times more often than the jobs with a relationship to data immediately below it on the DATA variable. The number of workers in a DOT job category was then computed by the following equation:

$$\text{Workers} = \frac{D_i E}{\Sigma N_i D_i}$$

where D_i is the weighting function defined below.

DATA Level (i)	D_i
0	17.09
1	11.39
2	7.59
3	5.06
4	$3.38(1.5)^3$
5	$2.25(1.5)^2$
6	1.5
7, 8	1.0

E is number of workers in the TMN occupational group.
N_i is number of job titles of DATA level i that fall within the TMN occupational group being considered.

For example, among the 16 DOT jobs classified under accountants, 12 "coordinate" data and 4 "analyze" data. The number of workers assigned here to each of the 12 jobs coded "1" is 29,274, while the number of workers in each of the four jobs coded "2" is 19,508. In other occupational groups, particularly those under "not elsewhere classified" categories, the spread of relationships to data is greater and the weighting more extreme than in this example.

3. "Downgrade data." Method 2 can be reversed so that jobs with

less complex relationships to data are emphasized. Then the number of workers in accounting jobs is 23,851 for each job coded "1" and 35,778 for each job coded "2."

4. "Single jobs." A much simpler method is to choose one or two jobs which are believed to be most typical (in terms of worker requirements) within each TMN occupational group, and to assign all the workers to these one or two jobs. Thus, not 14,000 jobs, but only 202 jobs (each related to one of the 161 occupational groups in TMN) form the basis of the projection developed by this method. In the case of accountants, the DOT job entitled "accountant" (DOT number 160.188) was chosen and assumed to have all 429,332 workers.

Table A-1 shows the distribution of relationships to data in 1960 and 1975 for the four methods described above. The result of upgrading or downgrading relationships to data within TMN categories leads, as expected, to somewhat different overall distributions. But the relative standing of each relationship is fairly constant. "Coordinating" is the most common relationship in all four cases. Four less common relationships to data — "synthesizing," "computing," "copying," and "comparing" — vary but never does any of them go over 4.5 percent of the labor force. The growth rates from 1960 to 1975 for the first three methods are also fairly stable. The growth rate for the fourth method — "single jobs" — varies much more than the others. "Comparing," for example, decreases 11 percent. Since in the fourth method relationships to data are spread over only 202 jobs, extreme results such as this are not unexpected.

Given the differences in complexity of job relationships to data, what happens with the other requirements? The results for general intelligence give an idea. In Table A-2, "upgrading" data leads to a greater frequency of high intelligence requirements, while "downgrading" data leads to lower intelligence requirements. We would expect this since complex relationships to data should be correlated with high intelligence. But the difference in distributions of intelligence requirements in all four methods are not so great as to change our conclusion that intelligence is in great demand. Similar results have been found for variable 29 STRENGTH, though they are not shown here.

TABLE A-1

Distribution of Relationships to Data According to Different Weightings

RELATIONSHIP	1. *Equal Weighting*			2. *Upgrade Data*			3. *Downgrade Data*			4. *Single Jobs*		
	1960	1975	Growth	1960	1975	Growth	1960	1975	Growth	1960	1975	Growth
0. Synthesizing	.019	.025	.74	.026	.034	.73	.012	.016	.74	.024	.031	.72
1. Coordinating	.226	.229	.35	.372	.363	.29	.150	.161	.42	.193	.177	.22
2. Analyzing	.115	.125	.45	.137	.146	.41	.094	.103	.46	.123	.146	.58
3. Compiling	.172	.185	.43	.186	.195	.39	.126	.138	.46	.189	.200	.41
4. Computing	.029	.032	.48	.025	.027	.46	.027	.030	.50	.026	.030	.53
5. Copying	.031	.035	.48	.016	.018	.46	.044	.049	.50	.023	.028	.62
6. Comparing	.019	.018	.23	.012	.011	.27	.030	.029	.29	.003	.002	−.11
8. No relationship	.388	.351	.21	.225	.206	.22	.518	.474	.22	.418	.386	.23

TABLE A-2

Distribution of Requirements for General Intelligence According to Different Weightings

Equivalent Level	1. *Equal Weighting*			2. *Upgrade Data*			3. *Downgrade Data*			4. *Single Jobs*		
	1960	1975	Growth	1960	1975	Growth	1960	1975	Growth	1960	1975	Growth
Top 10 percent of Working Population	.063	.075	.61	.069	.083	.60	.057	.068	.59	.096	.108	.50
Top 10 to 33.3 percent of Working Population	.191	.205	.44	.225	.233	.38	.159	.175	.46	.155	.173	.48
Middle 33.3 percent of Working Population	.492	.495	.35	.544	.536	.31	.473	.478	.34	.450	.452	.34
Lower 33.3 percent of Working Population	.253	.225	.18	.162	.148	.21	.311	.279	.19	.300	.267	.18

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The sources listed below are restricted to those which have been used directly in this work, or which approach highly similar questions (as in the case of the items by Eckaus and Scoville). No attempt is made to give a careful summary of the literature relating to occupational forecasting, or to the shape of the workforce in terms of its demands upon its human members.

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